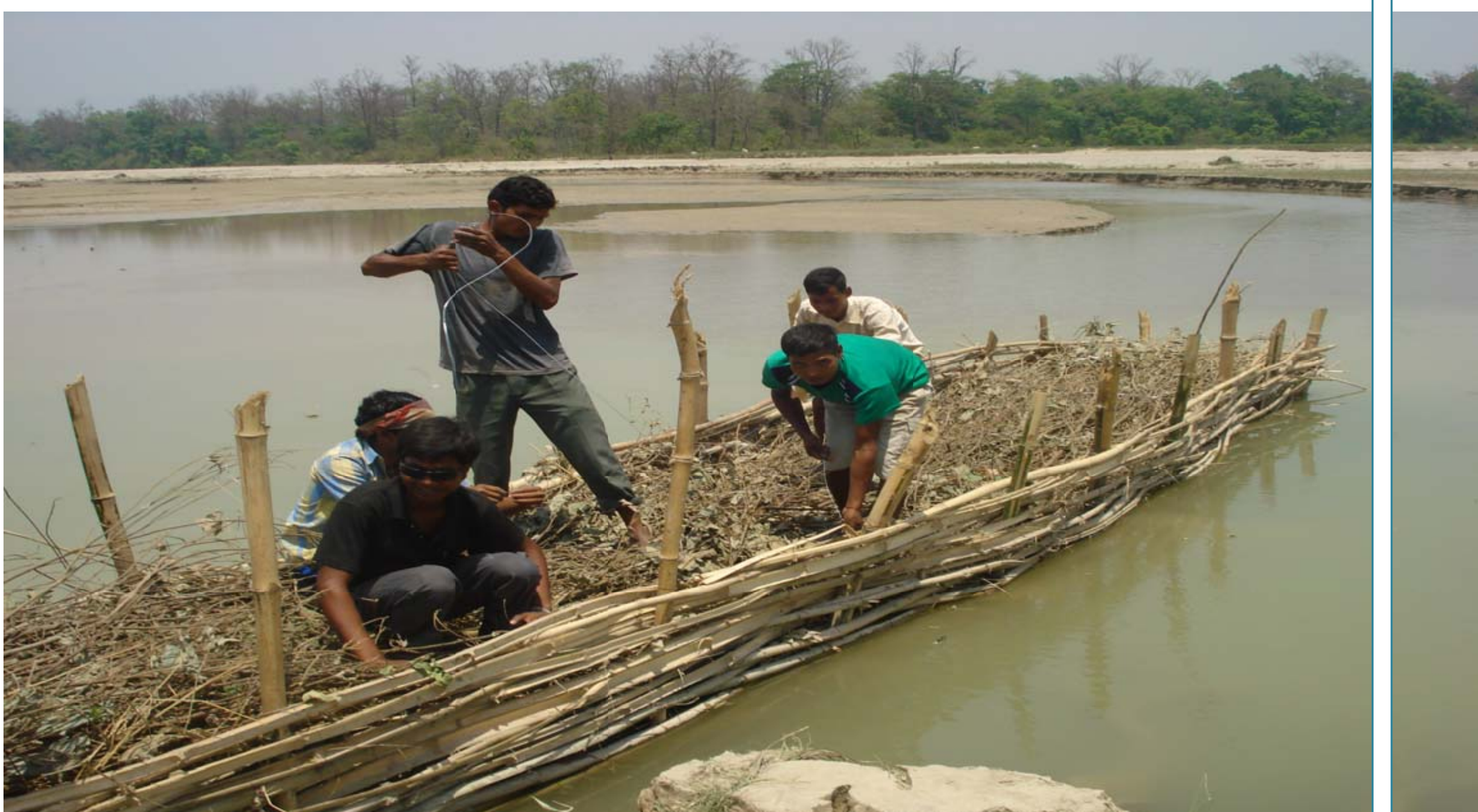
BAMBOO AND BIO –ENGINEERING INTERVENTIONS FOR MITIGATION OF RIVER BANK EROSION: A CASE STUDY

Kailali Disaster Risk Reduction Initiatives

11/11/2010

MERCY CORPS NEPAL
Ulla Dons

Contributors
Mohan Chandra Bishwakarma
Sagar Pokharel
Sagar Gautam



EUROPEAN COMMISSION
Humanitarian Aid

MercyCorps

Nepal Red Cross Society
Kailali

Table of Contents

I. Context

Floods are a major hazard in Nepal contributing to endemic poverty and this is likely to increase as climate change proceeds. The Siwalik range in the southern Nepal sees an annual sharp rise of water flows followed by a rapid recession. This often causes high flow velocities and little lapse time between the start of the flood and its peak discharge, leaving the population no or very short warning time. The ensuing flash floods damage agriculture land, crops, lives, property and livelihoods. Mercy Corps Nepal and the Nepal Red Cross Society (NRCS) - Kailali District Chapter have implemented two consecutive projects in the Far-Western Development Region of Nepal in order to prepare communities for such hazards. The projects were supported by the European Commission via its Humanitarian Aid and Civil Protection department (DG ECHO) under the DIPECHO Fourth and Fifth Action Plans for South Asia. The first project, the *Kailali Disaster Risk Reduction Initiatives I (KDRRI I)* was implemented in six communities between November 2007 and April 2009. The stated aim of this project was to build safer communities through Disaster Risk Reduction initiatives in collaboration with communities, local governments and other key stakeholders. Project interventions included local capacity building and training, early warning systems, small-scale mitigation, education, and facilitation of coordination. These activities are now expanded to an additional ten communities in five VDCs through the *Kailali Disaster Risk Reduction Initiatives II (KDRRI II)* from June 2009 to September 2010. Building upon the lessons learned and replicating the best practices of KDRRI I, the KDRRI II aim to contribute to the overall disaster risk reduction strategy in Nepal focusing primarily on support to local communities and institutions.

Primary problems faced by the communities supported under the KDRRI I and KDRRI II projects are inundation of settlement areas, erosion of river banks on the receding flood and aggravating the shifting tendencies of the river courses. During the monsoon season, heavy rainfall upstream in the watershed trigger flash floods resulting in catastrophic situations for downstream communities in the plain areas. The flood water carries huge amount of sediment causing the river bed to raise, undercutting of the toe of one bank and accumulation of sediment on the other bank. The inundation situation is further aggravated by back water when the tributaries meet the bigger Mohana River in the south with stable and confined banks on the Indian side of the river.

Photo 1: Bank erosions

The traditional measures for river bank protection suggested by technicians in Nepal are gabion structures and communities living along the rivers expect support from the government, donors, NGO/INGO for such structures. These measures might be relevant in some river systems, but have failed in the rivers in the areas of Kailali district supported by the KDRRI projects. Gabion structures have proved not feasible in rivers with sandy, silty or loamy types of soil as in the lower part of the Mohana River and its tributaries such as Kandra River and they cannot effectively solve the erosion problem. If gabion structures are constructed in areas with the kind of soil present in these areas, it will rather attract flow and facilitate erosion of surrounding soil, causing the failure of the structure itself[1].

---

[1] Report on *Assessment and Recommendation for Bio-Engineering Interventions along the Kandra River*, Padma Bahadur Khadka, January 2010.

Bamboo work and bio-engineering is an essential measure introduced by the projects for bank protection. Using bamboo walls for toe protection combined with plantation on the bank and the top of the river bank for stabilization of the river bank is the key to the success of these interventions. These techniques protect and stabilize river banks by preventing erosion and reducing shallow seated mass movement. The type of vegetation is important and should be carefully selected for this purpose. The methods used will catch debris, armor the surface, reinforce the soil, anchor the surface layer, and support the slope or drain water. Initially, the strength of the bamboo structures will be at its maximum, and its strength will gradually decrease as time pass by. The strength of the bio-engineering work will be relatively low in the initial phase and as the plants grow, the work will gain strength. Thus this combination of bamboo work and bio-engineering interventions gives a complete solution reducing the erosion and stabilizing the river banks.

The bio-engineering plants used come partly from the community nurseries established with the support of the projects, partly from areas around the communities and partly from other nurseries. Priorities are given to local species scrub, grass and trees to ensure the ecological balance and where possible to include fruit trees (i.e. banana) and species with a nutritious value or species which can be used for income generation. The species should further have deep and wide root net, be fast growing, the plants be of medium size plant and self regenerating.

The Kalali or DIPECHO project organized technical trainings (nursery management, bio-engineering techniques and quality control) for members of the community disaster preparedness committees and sub-committees for nursery management. The communities contributed with labor for the nurseries, bamboo and the bio-engineering interventions and all local material, while the project supported seed and seedlings and other material for establishment of the nurseries and wire and bamboo, where this were not available.

Sonu Ram Chaudhary, member of the disaster preparedness committee in Bishanpur knows the Mohan River like the back for his hand, swimming and fishing along its banks for the last 40 years. Not all memories of the river are positive. He has seen how the Mohana has changed it course and brought distress to his community. He still remembers the pain he suffered as child, when the whole community had to resettle due to heavy river erosion. The river has changed it course with more than 800 meter and cut more than 35 hectares of productive land.

When the project team first met Sonu Ram his reaction was: "We have tried everything from construction of raised embankment parallel to the river flow to plantation of besarmi plants along the bank and nothing has worked. What we need is a series of gabion structures otherwise we will be history"

Later when he was introduced to the project he said" We want to try the bio-engineering techniques and see if it works. We have some confidence in the technique, but let's see when the monsoon starts whether it works".

After the monsoon season his response was: "This year's flood was the biggest in 30 years and where we did the bio-engineering work we haven't lost any land to river erosion. We are impressed and plan to continue the work".

Bishanpur has now on their own replicated more than 550 meter of bank protection work and are planning for 200 meter more this year.

II. Techniques

A) This technique was introduced under the KDRRI project along the Mohana River:

Bamboo crib walls were constructed at the toe of the river bank (slope). Four meter long bamboo poles were driven 3 meter into the river bed (see photo 2) in two parallel rows forming the outer walls of the crib (see photo 3). The space between the two rows of bamboo poles is one meter and the same between the poles in the two rows. Bamboo poles were then split and woven in between the poles. The space between the two rows was filled with sand bags (see photo 4). The vertical bank was cut to slope angles less than 30 degrees (see photo 5). Sandbags were placed on the slopes up to the mean river level (see photo 6) and jute bags were place on the slopes above the mean river level (see photo 7). Scrubs were planted on the jute bags (see photo 8) and sand bags in order to stabilize the slopes. Seedlings from the community nurseries were transplanted (see photo 9) on the land adjacent the slopes to form a green belt which will further stabilize the soil and reduce the speed of the flood water. This technique can be combined with bamboo spurs or wooden spurs.

Material needed: bamboo poles, equipment to drive the poles into the river bed, used cement bags, sand, jute bags, wire, seedlings and plants (please refer to Annex I for species introduced).. Local material as sand and mud was the contribution from the communities.

Man power: Skilled labor is required to manage techniques for driving the bamboo poles into the river bed. The communities provided the additional manpower.

Challenges: Cement bags were quite high in demand and the cost fluctuated with the demand. The bags gets easily damaged and torn as they are exposed to hard weather conditions and kids who like to play on the bags. The technique requires supervision during plantation and regular maintenance of bamboo work and plantation. Areas with newly planted bio-engineering plants must be protected from grazing, firing and cutting.

Cost per 100 m work:

Material	Price (NPR)	Price (EUR)
Bamboo	NPR 13,150	EUR 138
Sand bags	NRP 32,000	EUR 337
Rope	NPR 5,000	EUR 53
Jute bags	NPR 4,436	EUR 47
Total	NPR 54,586	EUR 575

Photo 2: Placing bamboo poles

Photo 3: Bamboo crib wall

Photo 4: Filling crib wall with sand bags

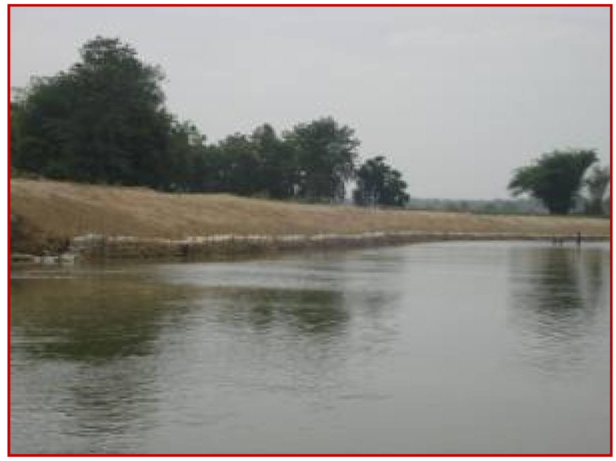


Photo 5: Bamboo crib wall and slope gradient

Photo 6: Sand bags on the slope

Photo 7: Jute bags on the slope

Photo 8: Plantation grass and scrubs

Photo 9: Plantation of green belt

Photo 10: Sediment depositied

Photo 11: Sediment deposited

B) This technique was introduced under the KDRRI II along the Kandra River:

Bamboo walls were constructed along the toe of the bank (see photo 15). A single row of four meter long bamboo poles were driven three meter down in the river bed (see photo 12). The poles were placed with one meter intervals and split bamboo woven in between the poles (see photo 13, 14). Bamboo spurs 10 to 15 meter long and 1.5 meter wide and filled with dead and live branches (see photo 16). These were placed with a distance of 15 to 20 meter. The morphology of the river (bends and width of the river) will determine the actual distance between two spurs and the length for the spurs. Sharp bends will require less distance between the spurs. The angle between the spur and the river bank should be 10 to 15 degrees in downstream direction (see photo 17). The first spur will be the shortest and each of the following spurs will be slightly longer than the front runner (see photo 18). These spurs will allow the water to pass and they will at the same time reduce the velocity. Sediment will be deposited (see photo 20 and 21) behind the spurs and the water current will be slightly diverted away from the bank. Seedlings from the community nurseries, plants locally collected and procured from other nurseries were transplanted on the slopes, at the toe of the bank and on the land adjacent the slopes to form a green belt (see photo 19) which will further stabilize the soil and reduce the speed of the flood water.

"Fifteen years ago the river was 500 m from our community, but now it just outside our door and over the last three to four years we have lost more than ten hectares of fertile land. We have done everything possible to control the river alone and with support from organizations and the government. Three times (1988, 2006 and 2008) gabion spurs were constructed to protect our community and each time four spurs. The last spurs lasted less than one season. The cost of the spurs has come up to more than NPR 1,500,000 plus our labor contribution. Because of our past experience we did not trust the bio-engineering techniques when it was first presented for us, but then we thought why not try it out. This year we haven't seen any cutting where we did the bio-engineering work. We have concluded that it will be foolish to invest more in gabion work as it will not work in the Kandra River. We are now planning to maintain and replicate the bio-engineering work along a longer stretch of the river.

(Serp Tamata, Disaster Preparedness Committee Coordinator, Kusumghat CommunityI)

Material needed: bamboo poles; live and dead branches; wire; equipment for driving the poles into the river bed, and bio-engineering plants (please refer to Annex I for species introduced). Local material as live and dead branches and mud is contribution from the communities.

Man power: Skilled labor is required managing techniques driving the bamboo poles into the river bed. The communities provide the additional manpower.

Challenges: The technique requires supervision during plantation and regular maintenance of bamboo work and plantation. Areas with newly planted bio-engineering plants must be protected from grazing, firing and cutting.

Cost per 100 m work:

Material	Price (NPR)	Price (EUR)
Bamboo	NRP 24,000	EUR 253
Wire	NPR 1,935	EUR 20
Total	NPR 25,935	EUR 273

Photo 12: Placing bamboo poles for bamboo spur

Photo 13: Splitting bamboo for crib wall

Photo 14: Bamboo weaving

Photo 15: Bamboo wall long the toe of the bank

Photo 16: Filling the bamboo spur

Photo 17: Bamboo wall and bamboo spur

Photo 18: Bamboo wall and bamboo spurs

Photo 19: Planting green belt

Photo 20: Sediment deposited

Photo 21: Sediment deposited behind bamboo spurs

III. Strategic Approach

Based on hazard mapping, site observations, observation of the morphology of the rivers the project decided with the communities to apply low tech, low cost, environmental healthy and easy replicable, long term solutions with the use of local material and other local resources such as bamboo and shrubs.

IV. Sustainability

It is essential to understand that bio-engineering systems can't always perform perfectly in the initial stage. It will take some seasons to grow the plants and perform the function. The success of bio-engineering intervention will depend on the maintenance systems set up by the communities. Routine and emergency maintenance should be introduced.

V. Impact

Positive impact of both techniques has been registered in terms of prevented or reduced bank erosion and extensive amount of sand deposited (see photo 19 and 20) along the river banks which slightly divert the flow of the water away from the affected areas. The opposite was carefully assessed in order to avoid any unnecessarily damage to those banks.

VI. Replication

Project communities have successfully replicated the techniques over stretches of more than 1,000 meter with their own means or with support from local authorities and/or organizations. The District Soil Conservation Office in Kailali have replicated 5,000 m of the bio-engineering interventions. Local NGOs in the district along with other partner organization have replicated the techniques in Kailali (i.e. the NGO BASE 300 m) and in a number flood prone district in the Tarai.

Kusumghat school on the bank of Kandra River is often closed during the rainy season. Over the last five years the school has lost one hectare playground land and two buildings, and had one building damaged due to river bank erosion. Mr. Upendra Jha, Principal of Kusumghat School tells that; "School activities are severely affected by the loss of facilities and frequent closure. We have constructed gabion embankment to control the river cutting, but with no success. We planned to relocate the school, but after seeing the effect of the bio-engineering work, we have decided to postpone the relocation and focus on replication of the bio-engineering work".

References

1. Acharya, D.P., Gautam, M. 1992. *Management of Forest Nurseries*. Community Forestry Development Project (PhaseII). HMG/UNDP/FAO. Sigma Offset Press, Kamaladi, Kathmandu, Nepal. http://www.fao.org/docrep/006/ad225e/ad225e00.htm.
2. DoSCWM, 2004. *Soil Conservation and Watershed Management Measures and Low Cost Techniques*. Soil conservation and watershed management component (NARMSAP), Department of Soil Conservation and Watershed Management, Baber Mahal, Kathmandu Nepal.
3. MoWR, 1999. *Improvement of Technical Manuals for River Training Works*. Water Induced Disaster Prevention Technical Centre , Ministry of Water Resources, Pulchowk, Lalitpur, Nepal. Vol-I.
4. Gautam, D.R., Bhatta, K.R., Sharma, P.R. and Fath. J. 2009. Final Evaluation Report of Kailali Disaster Risk Reduction Initiatives. A report submitted to Mercy Corps Nepal.
5. Howell, J 1999. *Roadside Bio-engineering*. His Majesty's Government of Nepal. Department of Roads, Babar Mahal, Kathmandu, Nepal.
6. Jackson, J.K 1994. *Manual of Afforestation in Nepal*. Forest Research and Survey Centre. Ministry of Forest and Soil Conservation, Kathmandu Nepal. Vol-1.
7. Khadaka, P.B 2009. *An assessment of river morphology and suitable bio-engineering interventions in Kandra river, Kailali*. A technical report submitted to Mercy Corps Nepal.
8. Singh, A.M 2008, *Review Report on Flood Control Measures,* A technical report submitted to Mercy Corps Nepal
9. Thakur,R. B 2003. *Compendium of Tree Species of Nepal*. Sarvottam offset printing press (P.) Ltd. Putalisadak Kathamandu, Nepal. First edition.

Annex – Bio-engineering species

A. Trees

1. Khair (*Acacia catechu*)
2. Ipil Ipil (*Leucaena leucocephala*)
3. Amala (*Phyllanthus emblica*)
4. Tanki (*Bauhinia purpurea*)
5. Bainsh (*Salix tetrasperma*)
6. Sisoo (*Dalbergia sisoo*)
7. Gulmohar (*Delonix regia*)
8. Kimbu (*Morus alba*)

B. Shrubs/herbs

1. Bamboo (*Dendrocalamus species*)
2. Bet/Rattan (*Bambusa species*)
3. Bihaya/Besarmi/Saruwa (*Impomea fistulosa*)
4. Kans (*Saccharum spontaneum*)
5. Khar (*Cymbopogan microtheca*)
6. Narkat (*Arundo clonax*)

Contact:

Mercy Corps
Sanepa Chowk,
Lalitpur, Nepal
Phone: +977 1 5555532
Mobile: +977 9803417998

Mercy Corps Far Western Area Office
Dhangadi – 5, Hasanpur
Kailali, Nepal
Phone: +977 91 526923
Mobile: +977 9741174127

EUROPEAN COMMISSION
Humanitarian Aid

MercyCorps

Nepal Red Cross Society
Kailali